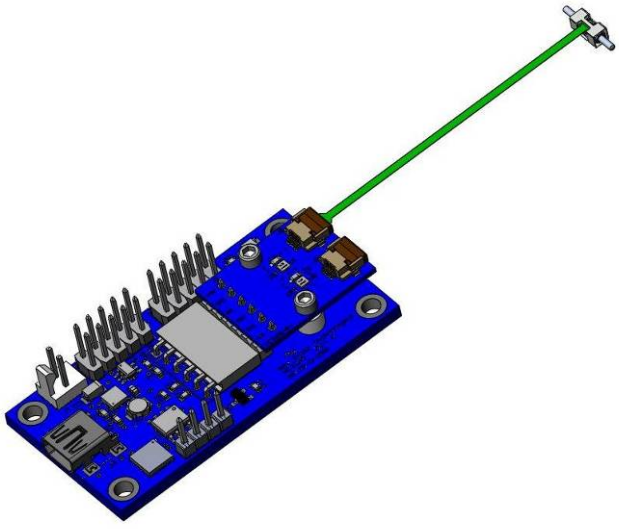
NEW SCALE TECHNOLOGIES
Ingeniously Small Motion Systems

squiggle® MOTORS

MC-3300-RV Motor Controller for SQL-RV-1.8 Series Reduced Voltage SQUIGGLE® Motors

User Manual



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Introduction

The MC-3300-RV (**R**educed **V**oltage) Motor Controller generates ultrasonic signals to drive two SQL-RV-1.8 Series SQUIGGLE Motors in open-loop or closed-loop operation.

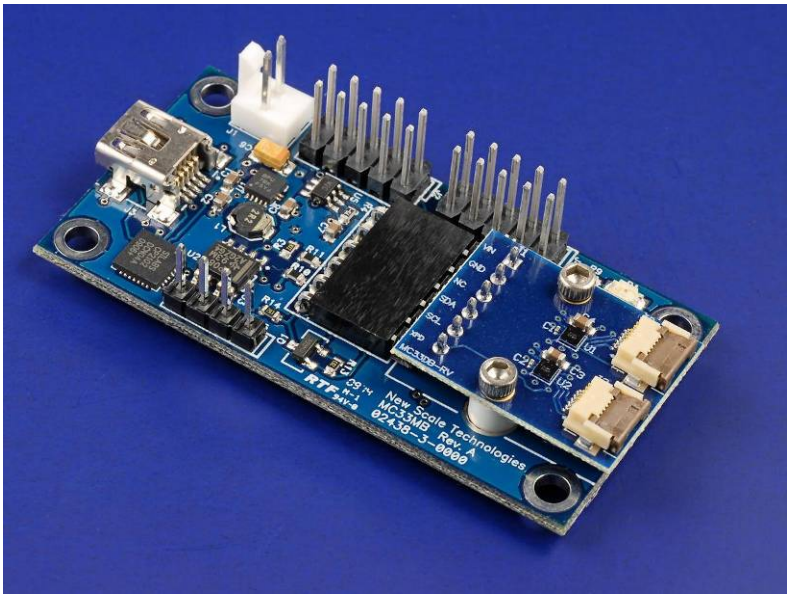


Figure 1. MC-3300-RV Motor Controller for SQL-1.8 RV Series SQUIGGLE® Motors

The controller sends drive signals to one or two SQUIGGLE motors based on the input from a computer or a manual handset.

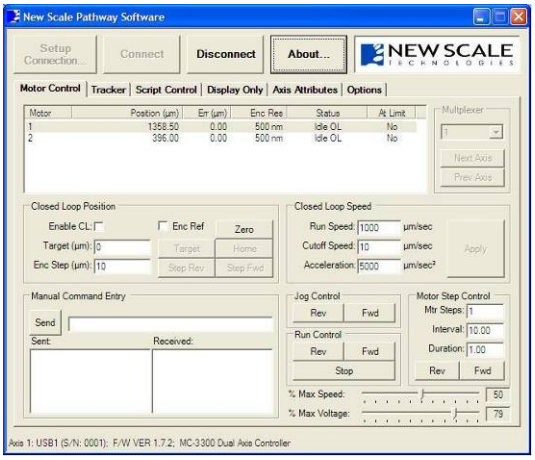
- **Computer Control** – Connect the MC-3300-RV to a PC USB port: The control software enables simple point-and-click operation of the motor. You can also build and run scripts using the intuitive scripting environment, or write routines using your own software and the included ActiveX function library.
- **Manual Control** – Use the optional handset to control the motor (See page **Error! Bookmark not defined.**).

New Scale Pathway Software

The control software provided with the MC-3300-RV Motor Controller enables point-and-click control via a PC USB port. It also includes a scripting interface and an ActiveX command library.

Each MC-3300-RV Motor Controller can operate one or two SQUIGGLE motors, and you can manage multiple motor controllers simultaneously from a single control software window.

The control software and scripting interface allow you to easily evaluate open-loop and closed-loop performance of SQL Series SQUIGGLE motors.



Open-Loop or Closed-Loop Operation

We recommend closed-loop operation when repeatable step size, absolute position or precise velocity control is needed. The MC-3300-RV accepts input from remote position sensors or switches for closed-loop motion control.

With a digital (incremental) encoder as a position sensor, the resolution of the encoder determines closed-loop position resolution. With an analog position sensor, closed-loop position resolution is determined by the A/D converter, the resolution of the position sensor, and the resolution of the motor. For more information see the New Scale Application Note: *Creating Closed-Loop Positioning Systems Using SQUIGGLE Motors*.

In open-loop mode, you can calibrate a motor's average step size in response to a number of drive pulses. Open-loop resolution is listed on the motor data sheets.

Mother Board/Daughter Board Configuration

The MC-3300-RV Motor Controller is a mother board/daughter board configuration. The mother board includes the processor, position sensor input with 12-bit A/D converter, limit switch input and PC/handset interface. The daughter board contains the motor driver ASIC, related boost circuit, and two motor connectors.

Both the daughter board (MC-33DB-RV) and ASICs (two NSD-2101) are also available separately for integration into OEM systems. See the separate data sheets for more information. We work closely with OEM customers to develop integrated SQUIGGLE motor systems including position sensors, housings, and controllers designed for your unique needs.

Difference between MC-3300 and MC-3300-RV

The MC-3300 Motor Controller uses the MC-33DB daughter board which incorporates a single NSD-1202 dual motor driver ASIC. This ASIC uses an external inductor, diode and capacitor to boost the supply voltage (2.3V to 5.5V) to up to 40V to drive the SQL motor. One ASIC drives up to two motors.

The **MC-3300-RV** Motor Controller uses the **MC-33DB-RV** daughter board which incorporates two NSD-2101 driver ASICs. Each ASIC can drive a single SQL-RV-1.8 motor at the supply voltage (2.3V to 5.5V, there's no voltage boost). The NSD-2101 ASIC, in the WLCSP package is much smaller than the NSD-1202 QFN (1.8x1.8mm vs. 4x4mm) and it requires only two external capacitors (0.47 uF and 10 uF respectively).

The SQL-RV-1.8 motors, although the same size as the SQL-1.8 motors use multi-layer piezo plates rather than the single layer piezos used by the SQL-1.8 motors. These extra layers boost the motor capacitance and reduce the required voltage needed to achieve equivalent motor performance.

System requirements

- Computer with a CD drive; Windows 2000, XP Pro or Vista.

Safety

Review the following safety precautions to prevent injury and avoid damage to this product. Use this product only as specified. Service procedures should only be performed by qualified personnel.

Follow these guidelines to insure safe and reliable operation of this product:

- **Use Proper Power Cord.** Use only the power cord specified for this product and certified for the country of use.
- **Connect and Disconnect Properly.** Do not connect or disconnect components while power is on. Unplug the power connection from the back of the unit before connecting or disconnecting any cables.
- **Avoid Physical Shocks to the Motor.** The motor contains a piezoelectric actuator susceptible to excessive shock
- **Do Not Apply Side Loads the Motor Shaft.** Excessive side loads may damage the motor. Always apply loads axially to the motor shaft.
- **Do Not Retract Beyond Limit.** Do not allow the motor to overrun its travel limits when moving backwards. The threaded shaft may disengage from the internal threads. If this happens gently re-insert the screw until the threads are re-engaged and turning smoothly.
- **Avoid Contact with Internal Electronic Circuitry.** High voltage is present inside the controller and motor when activated. Do not touch connections and components when power is on.
- **Call Us If You Have a Problem or Question.** If your system is not operating within specifications or you have questions please contact us. Our service and support team is eager to help.

General Safety Summary

- Do Not Operate in Wet/Damp Conditions.
- Do Not Operate in an Explosive Atmosphere.
- Do not Operating in the corona vacuum pressure range from 100 Torr to 10^{-3} Torr.
- Keep Product Surfaces Clean and Dry.

Safety Terms and Symbols

This symbol indicates potentially dangerous voltages may be present when the motor is operating.

Only use an approved DC power supply or as provided by New Scale Technologies, Inc.

Certain components are susceptible to damage from electrostatic discharge. Observe all ESD procedures to avoid component damage

Warnings and Cautions

These terms may appear in this manual:

WARNING identifies conditions or practices that could result in damage, injury or loss of life.

CAUTION identifies conditions or practices that could result in damage to this product or other property.

DANGER indicates an injury hazard immediately accessible as you read the marking.

Set up the SQUIGGLE® Motor

Use the following instructions to set up and begin using your SQUIGGLE® motor and MC-3300-RV controller. If you have purchased a Developer's Kit, connections will already have been made. Proceed to Section 2 below.

1. Connect the motor(s) to the controller.

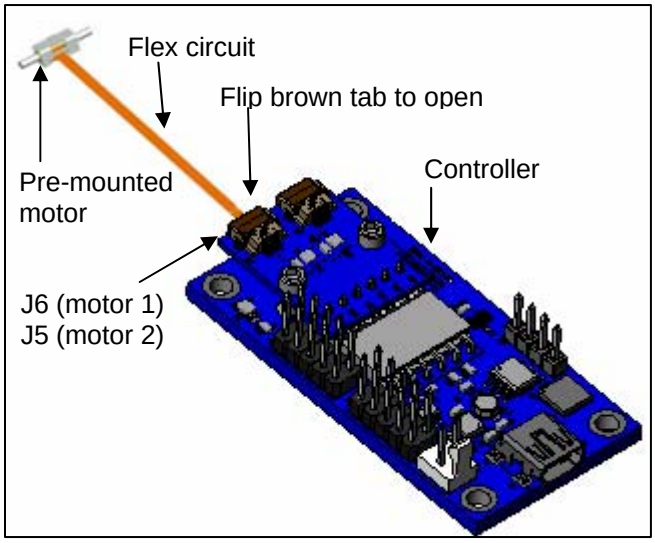
You can connect the motor directly to the controller, or use the extension cable (provided) if you need more length between the motor and controller. The MC-3300-RV controller is capable of driving to one or two motors.

a. Direct Connection

Flip up the brown tab on the controller daughter board at J6 (and J5, if you have two motors).

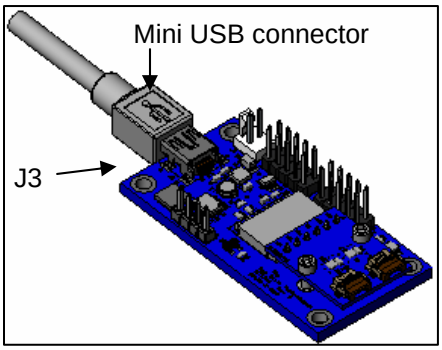
With the copper connection side down, gently slide the motor flex circuit into place. Close the tab.

Caution: Allow some bend in the flex circuit to avoid damaging solder connections.



2. Connect the controller to your PC or handset

Connect the Mini USB connector to the controller at **J3** on the mother board. Then connect the USB cable to your computer.

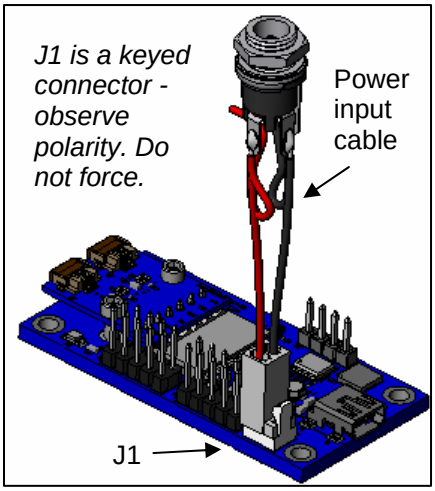


3. Connect the power

If you have purchased a Developer's Kit, batteries are provided, so there is no need to connect an input cable and external power supply. Press the On/Off switch on the Developer Kit to the "On" position and proceed to Section 4.

Connect the power input cable to the controller at **J1** on the mother board.

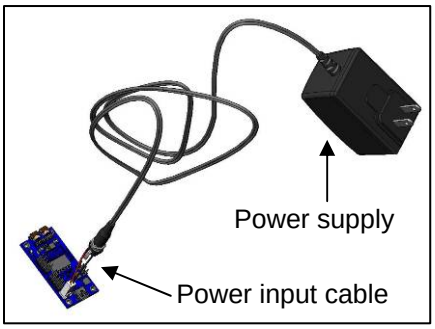
Caution: The power input cable has a keyed connector that fits only one way. It should never be forced. The **red wire** should connect to **pin 1**.



Plug the power input cable into the power supply.

Be sure to connect the power input cable to the controller **before** you apply power.

Plug the power supply to a power source. An LED on the controller lights when power is applied.



Install the New Scale Software

Next, install the New Scale software to control the motor from your PC.
(You may skip this step if you will be using ONLY the optional manual handset.)

a. Locate the software installation disk.

b. Place the disk in the computer drive.

The NST installer window will appear automatically.

Do not connect the MC-3300-RV controller yet!

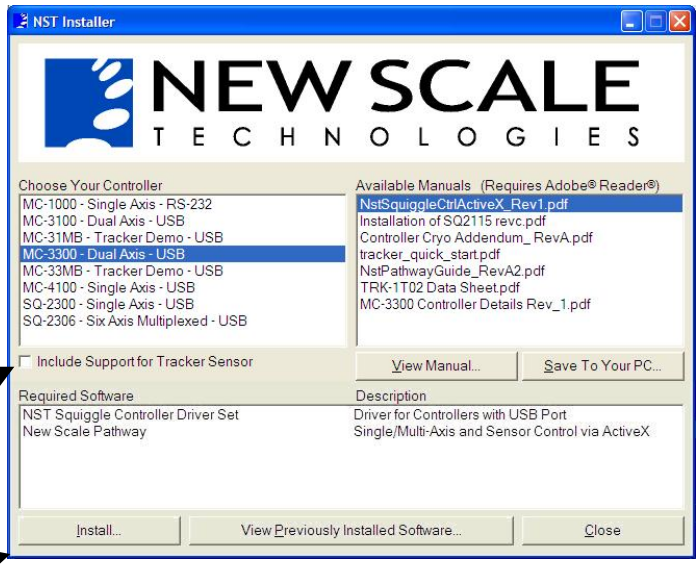
c. Identify the motor/encoder controller provided with your order.

d. Select the controller from the list in the "Choose Your Controller" menu.

e. If an encoder is included in the order, check the "Include Support for Tracker Sensor" check box.

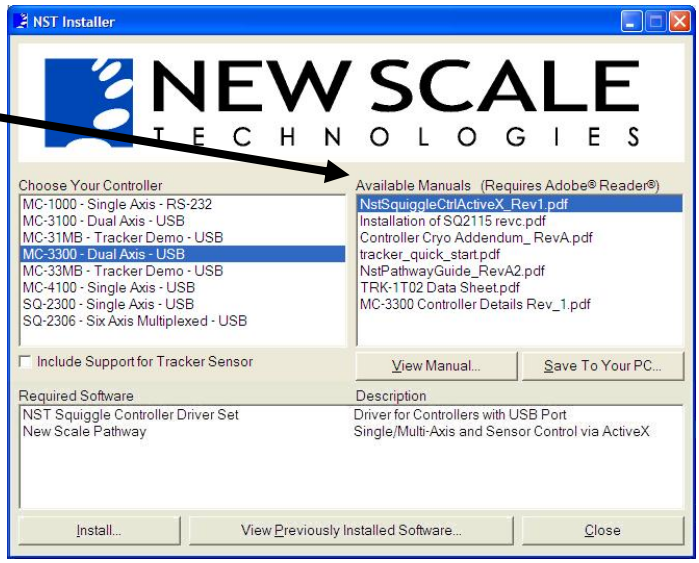
f. Click "Install" to install the software.

If a Microsoft warning appears, click OK to continue.



You may also view the New Scale manuals or save them to disk at this time.

When the installation is complete, remove the disk.



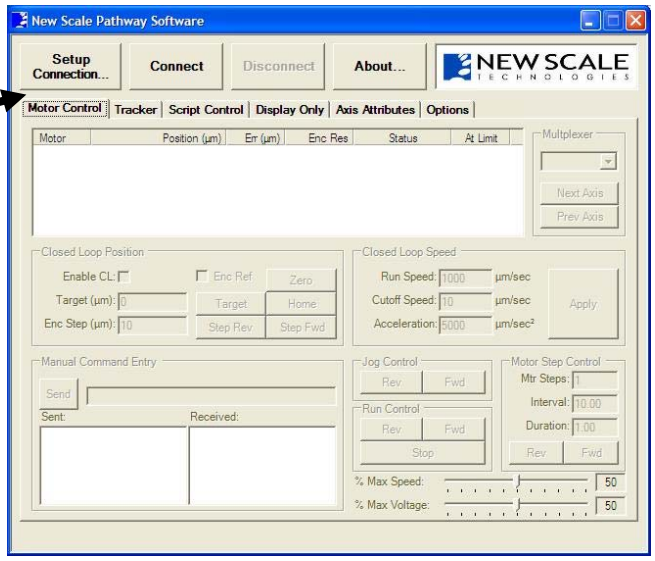
g. Connect the USB cable from the computer to the controller as shown.

The first time the USB connection is made, the system will install a USB driver and motor driver on the local hard drive

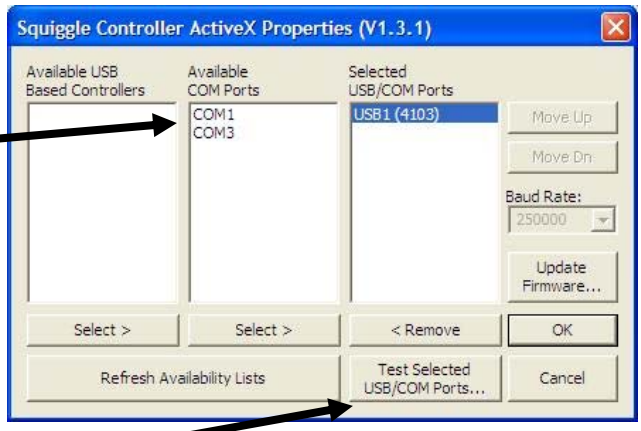
Instruct the system to find the drivers locally.

Do the following to run the Pathway demo software and select the communication port.

h. Double Click on the New Scale Pathways icon on desktop to start application.



i. Click on "Setup Connection" to open connection dialog.



j. Select the desired USB port (that you wish to connect the controller to).

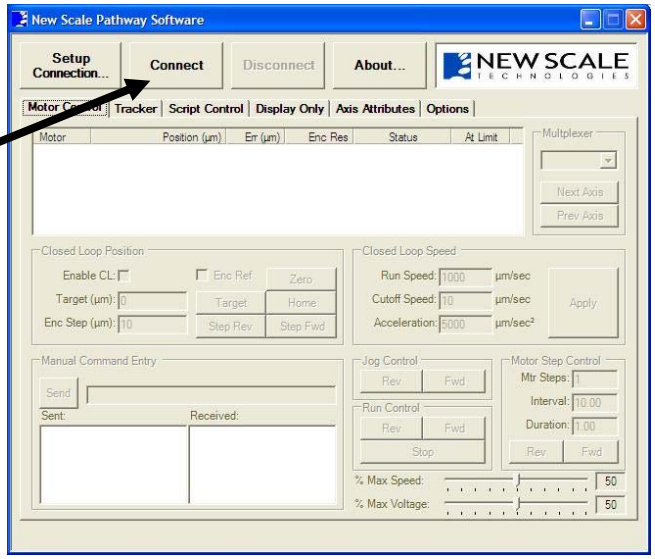
Highlight the desired USB port and click "Select" to select the port.

k. Click the "Test Selected USB/COM Ports…" button to test the selected port.

Click "Close" when the connection is complete.

4. Begin Using the Motor

- Click the **Connect** button in the main menu to connect to the controller.



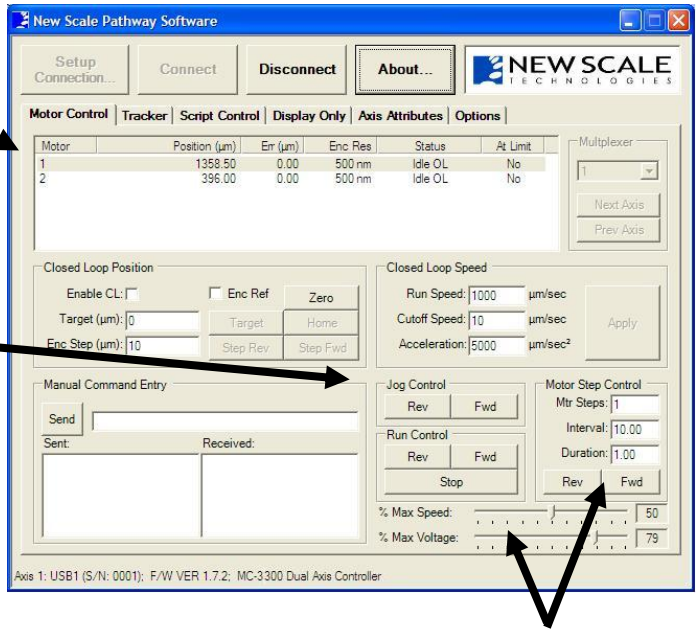
- Two motors are always listed in the motor control window.

  Highlight the desired motor.

- Click the **Fwd** and **Rev** Run Control and Jog Control buttons to move the motor as you observe motor operation.

  Encoder equipper systems will display position.

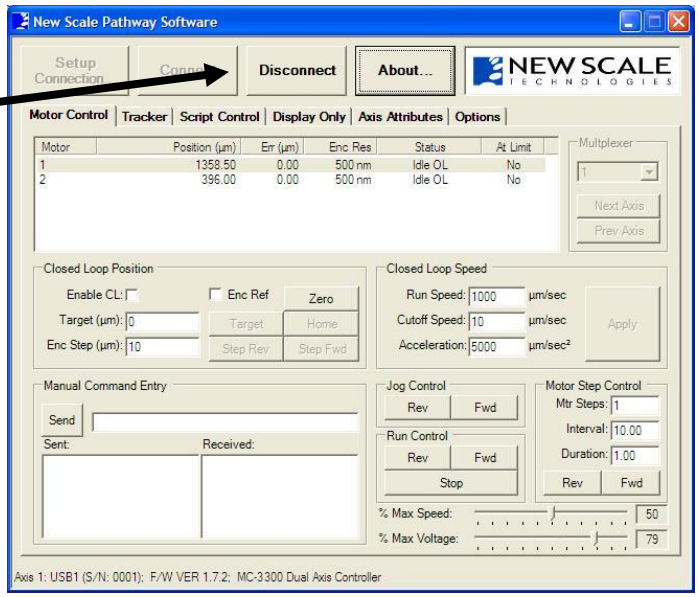
  See the New Scale Pathways Software manual for more detailed operating instructions.



To change the motor speed: change the **Motor Step Control** values or use the **%Max Speed slide bar**. Note that the motor step values are only used with the **Rev** & **Fwd** buttons contained within the same group box.

IMPORTANT NOTE:

When you wish to shut down the controller click the **Disconnect** button before you remove the USB cable.



- **Test encoder (Tracker) operation.**
  Select the Tracker tab to display the Tracker data screen, which shows available axes plus detailed information for encoder program development.

  See the New Scale Pathways Software manual for full programming details.

5. What's Next?

Consult the **SQL-RV-1.8 Series SQUIGGLE® Motors Use Manual** or **New Scale Pathway Software Manual** on the enclosed CD for more details on how to use the controller to drive the SQUIGGLE motor.

Your SQL-RV-1.8 SQUIGGLE motor is mounted in a sheet metal frame. Refer to the *Mechanical Integration* section of the **SQL-RV-1.8 Series SQUIGGLE® Motors Use Manual** for details on how to mount and integrate the SQL-RV-1.8 motor into your product.

Contact New Scale if you need assistance with your evaluation unit, or to discuss custom motors and motion control modules.

The MC-3300-RV Controller Pin Connections

The MC-3300-RV consists of two printed circuit boards: A mother board, which contains the power, PC/Handset, position sensor and travel limit interfaces, and a daughter board which contains the motor driver ASIC (NSD-2101) and motor connector interface. The daughter board may be removed and interfaced to 3rd party hardware as it supports an I2C command interface.

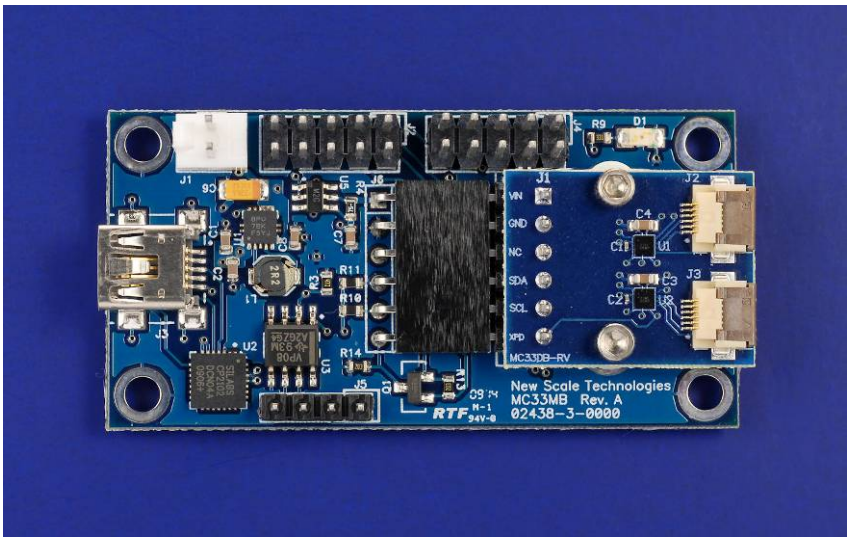


Figure 2. MC-3300-RV Controller Pin Connections

Power Connector (J1)

Pin	Pin Name	Description
1	Vin	Main supply input (2.3 to 5.5 volts).
2	GND	Ground reference

Analog and Limit Flag Input Connector (J2)

Pin	Pin Name	Description
1	AN5	Axis (Motor) 1 Quadrature Input B
2	INT1	Axis 1 (Motor) AF Reverse Limit. Active Low
3	AN4	Axis 1 (Motor) Quadrature Input A
4	INT0	Axis 1 (Motor) AF Forward Limit. Active Low
5	AN3	Axis 2 (Motor) Quadrature Input B (or Axis 2 Analog Sensor Input)
6	RD3	Axis 2 (Motor) Zoom Reverse Limit. Active Low
7	AN2	Axis 2 (Motor) Quadrature Input A (or Axis 1 Analog Sensor Input)
8	RD2	Axis 2 (Motor) Zoom Forward Limit. Active Low
9	Vcc	3.3 Volts
10	GND	Ground Connection

Note: AN5 and AN4 are connected to the processor's internal quadrature counter. AN3 and AN2 are polled in firmware. This limits either the resolution of the incremental encoder for Axis (Motor) 2 or the maximum speed of Axis 2 so that encoder edges are not missed.

USB Connector (J3)

This is a standard USB connector jack. The pins beneath the jack are defined as follows.

Pin	Pin Name	Description
1	Vbus	USB Voltage
2	D+	Data
3	D-	Data
4	GND	Ground
5	Shell	Shell Connection to Ground
6	Shell	Shell Connection to Ground

Program Connector (J4)

Pin	Pin Name	Description
1	PDC	dsPIC data clock
2	Vcc	3.3 Volts
3	PGD	dsPIC data
4	VIN	Power from J1 pin 1
5	/MCLR	Processor reset and Vpp program voltage connect
6	GND	Ground connection
7	SDA	I2C Data Line
8	ACM	Analog Drive Current Monitor
9	SCL	I2C Clock Line
10	NC	Not Connected

SQ-2301/SQ-2301M Multi-Axis (Motor) Handset Connector (J5)

The SQ-2301M may be used to control motor 1 or 2.

Pin	Pin Name	Description
1	Vcc	3.3 Volts
2	GND	Ground connection
3	B	RS485 connection B
4	A	RS485 connection A

Mother/Daughter Board Connector (J6)

Pin	Pin Name	Description
1	VIN	Power from J1 pin 1 (2.3V to 5.5V)
2	GND	Ground connection
3	NC	Not used by MC-33DB-RV
4	SDA	I2C Data Line
5	SCL	I2C Clock Line
6	XPD	NSD-2101 Enable Line

Daughter Board Motor Connectors (J3, J4)

Use these connectors if you use the motor extension cable.

If the forward direction of motion is the opposite of what you would like, reverse the FOUT1/ZOUT1 and FOUT2/ZOUT2 connections.

Pin	Pin Name	Description
1	FOUT1/ZOUT1	Motor Focus (J2) or Zoom (J6) Phase 1
2	GND	Motor return connect
3	FOUT2/ZOUT2	Motor Focus (J2) or Zoom (J6) Phase 2

Daughter Board Motor Flex Circuit FPC Connectors (J6, J5)

Use these connectors if you are connecting the motor flex circuit directly to the MC-3300-RV Controller without using the extension cable.

Pin	Pin Name	Description
1	GND	Motor return connect
2	GND	Motor return connect
3	FOUT1/ZOUT1	Motor Focus (J6) or Zoom (J5) Phase 1
4	FOUT2/ZOUT2	Motor Focus (J6) or Zoom (J5) Phase 2
5	FOUT1/ZOUT1	Motor Focus (J6) or Zoom (J5) Phase 1
6	FOUT2/ZOUT2	Motor Focus (J6) or Zoom (J5) Phase 2

Specifications

MC-3300-RV Controller

Item	Specification
Input power	2.3 to 5.5 V DC
Output signals	Motor 1 – Phase 1, Phase 2, Ground Motor 2 – Phase 1, Phase 2, Ground
Computer control	Via USB port Demo software and ActiveX command library included
Position sensor input	Digital or analog
A / D converter resolution	12 bits
Manual commands	See Appendix C
Dimensions (L x W x H)	1.150 x 2.275 x 0.875 inches (29.21 x 57.785 x 22.225 mm)

New Scale Pathway Software

System Requirements
PC running Windows XP or Vista 20 MB storage (minimal)

SQL-RV-1.8 Motor

Electrical specifications below assume that the motor is driven by an MC-3300-RV controller.

Item	**SQL-RV-1.8**
Travel range	6 mm SQL-RV-1.8-6-12: 12 mm screw length
Stator dimensions	1.82 x 1.82 x 6 mm
Housing dimensions	2.8 x 2.8 x 6 mm
Stall force	30 gram force (0.3 N)
Speed at ½ stall force	≥7 mm/s
Resolution	0.5 µm
Input power to MC-3300-RV (moving)	1.45 W
Input power to motor (moving)	< 500 mW (direct drive)
Input power (stopped)	0 mW (0 V) to hold position
Lifetime (load-dependent)	>1,000,000 cycles
Operating temperature	-30 to +80 degrees C
Storage temperature	-40 to +85 degrees C
Shock resistance	2500 Gs
Operating frequency	~ 171 KHz
Capacitance per phase	~ 42 nF
Mounting	Potting or flange; see the Mounting section of the *SQL-RV-1.8 Series SQUIGGLE® Motors* User Manual.
Weight	0.16 grams

Troubleshooting

Troubleshooting chart

If the following remedies do not work, call New Scale Technologies for service.

Symptom	Causes	Remedies
Controller LED does not light.	Power supply not connected or improperly connected.	Connect the power input cable to the controller at **J1** on the mother board. **Caution**: The power input cable has a keyed connector that fits only one way. It should never be forced. The **red wire** should connect to **pin 1**.
	Controller set on metallic surface.	Properly insulate the bottom of the controller.
Motor does not move.	Motor incorrectly installed.	Lift tab on FPC connector and fully insert motor connector.
	Wrong axis (motor) selected in New Scale Pathways software.	Select the correct axis (motor) on the Motor Control tab of the New Scale Pathways software..
	Too much load on motor.	Check the Test Data sheet shipped with the motor and motor specifications for maximum motor load.
	Motor shorted.	Move metallic surfaces away from the motor.
	Crimped or broken flex circuit.	Check for damage to the flex circuit.
Motor moved initially but stopped moving.	Too much progressive load on motor.	Reduce progressive load.
	Dirty screw.	Clean screw. See “Cleaning the Screw” on page 21.
	Controller timeout error.	Recycle power and restart Demo software.
Motor does not push to spec.	Motor mount not securely fastened.	Verify that motor mount is securely fastened to your test bench or fixture.
	Too much load on motor.	Reduce motor load.
Slow motor speed.	Low speed setting in Demo software.	Raise the speed setting in the Demo software.
	Dirty screw.	Clean screw. See “Cleaning the Screw” on page 21.
	Too much load on motor.	Reduce the motor load. Check mounting fixture.

Symptom	Causes	Remedies
No available USB-based controllers listed after using **Setup Connection** button.	The USB driver may not be installed or after the controller was connected to the PC and powered, Windows may have asked to reinstalled the driver and this request was ignored by the operator	Reinsert the NST demo software CD and select the MC-3300-RV controller to see if the USB driver must be installed. If it is shown, click Install to force an installation. If it's not shown in the list box below, it is already on the system. If already installed, disconnect and reconnect the USB cable and see if Windows prompts to reinstall the driver, if so, let it find the driver locally.
Screw runs completely out of motor shaft.	Motor run for too long in one direction.	Re-thread the screw. See "Re-threading the Screw" on page 21.

Maintenance

Re-threading the Screw

If you run the motor for too long in one direction, it can run completely out of the motor shaft.

If this occurs, carefully re-thread the screw clockwise, with either end facing into the motor shaft.

Cleaning the Screw

The SQUIGGLE motor normally performs well in an open setting without any contamination. This is true whether or not the motor is integrated in a module or housing.

Occasionally, dirt particles may accumulate on the screw, which can reduce motor performance. If this happens, clean the screw.

To Clean the Screw:

1. Clean the screw using acetone in an ultrasonic cleaner. If an ultrasonic cleaner is not available, simply rinse the screw with acetone.
2. Allow the screw to air dry or dry it using clean compressed air, such as an air can duster.

Schematics

This section includes top layout view of each board followed by the schematics.

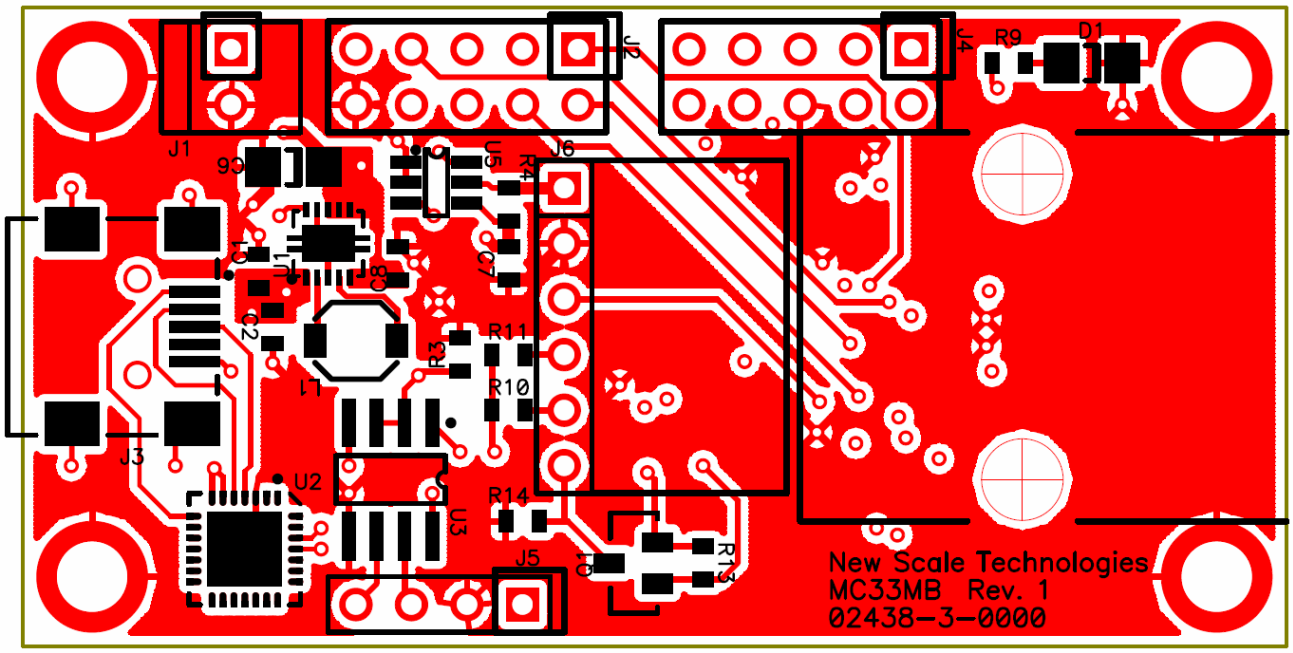


Figure 3. Mother Board Layout.

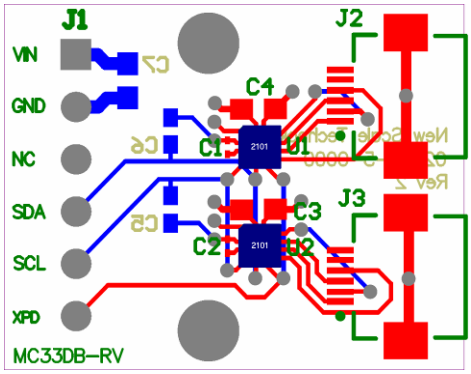


Figure 4. Daughter Board Layout.

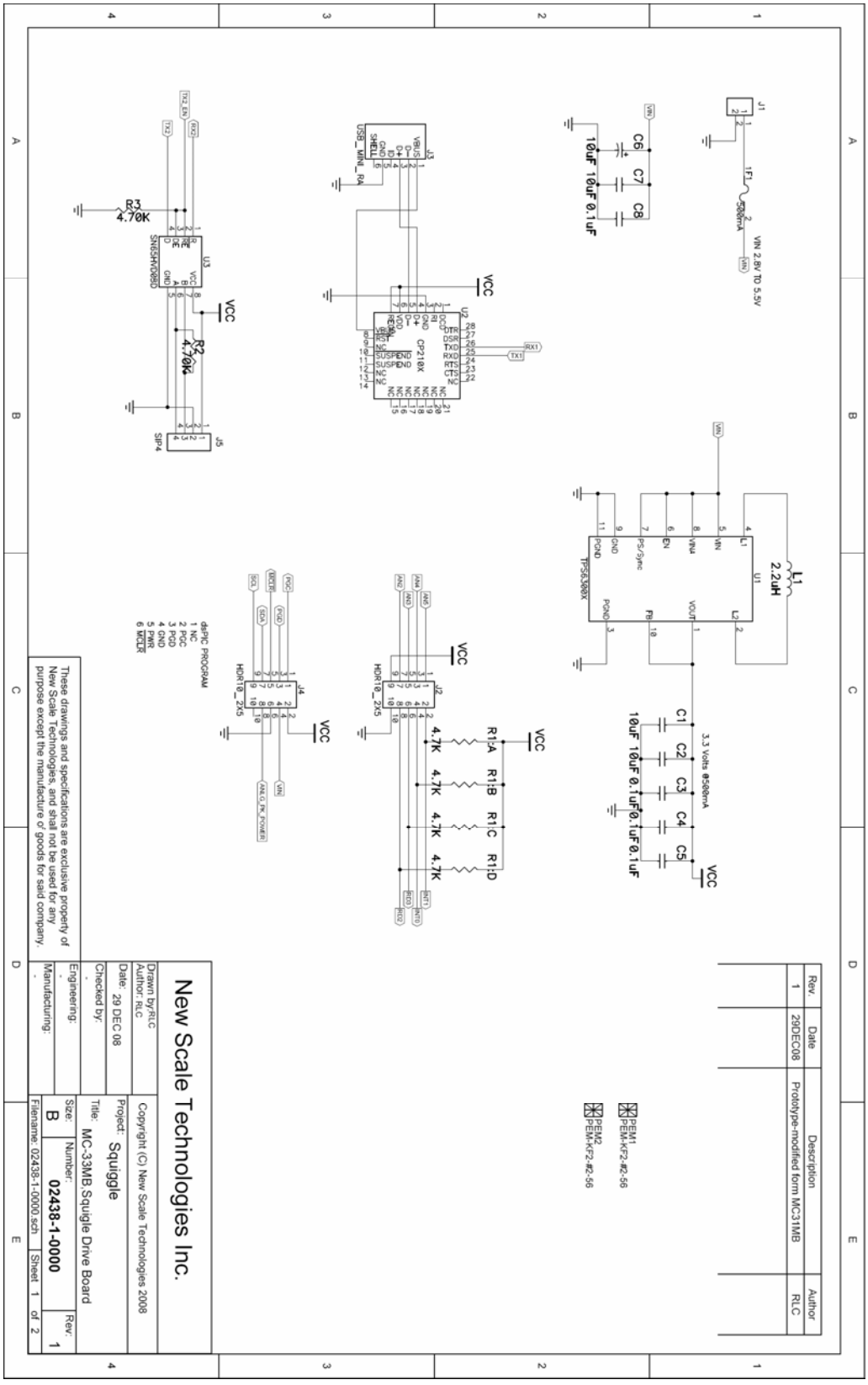


Figure 5. Mother Board Schematic (1 of 2).

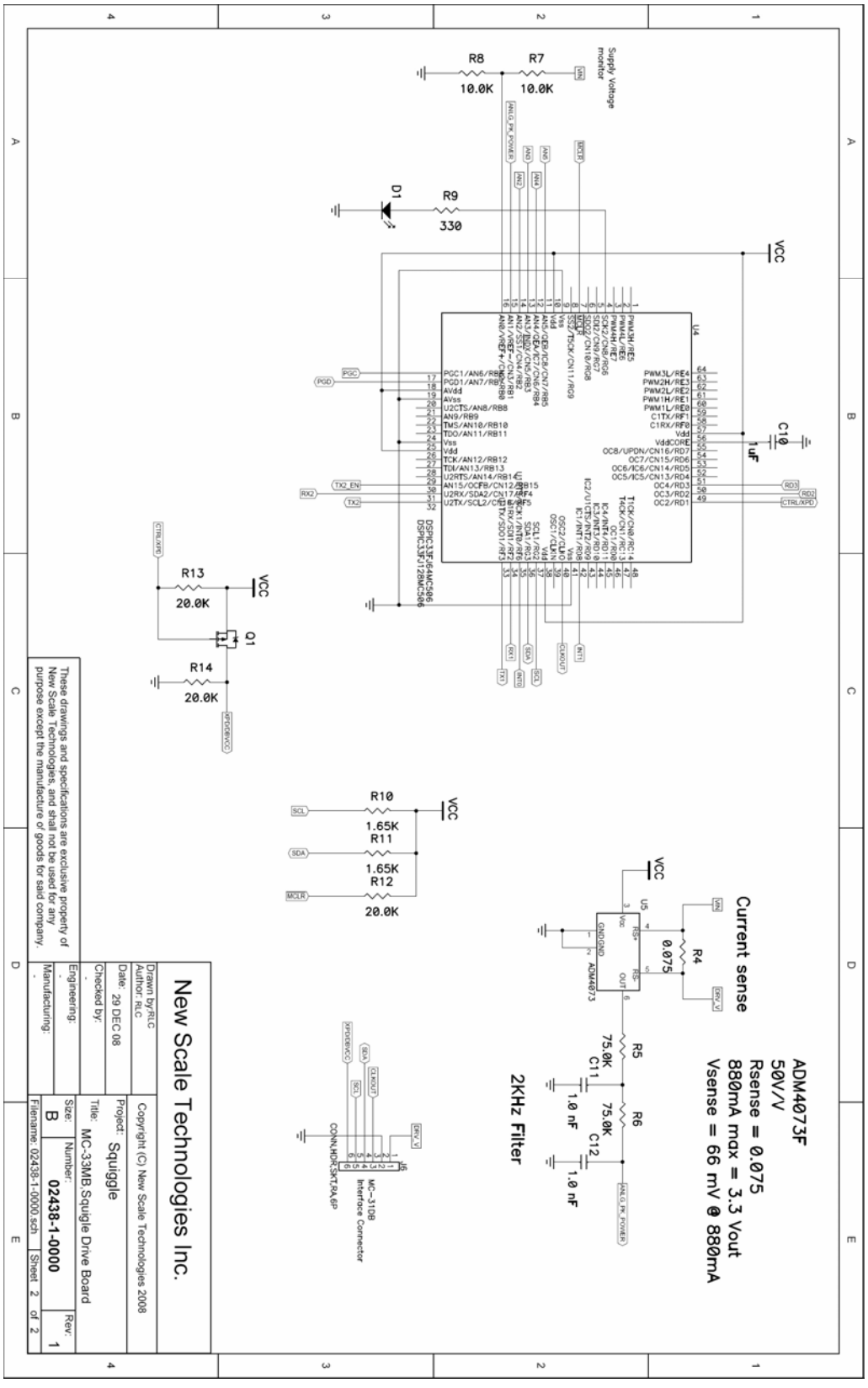


Figure 6. Mother Board Schematic (2 of 2).

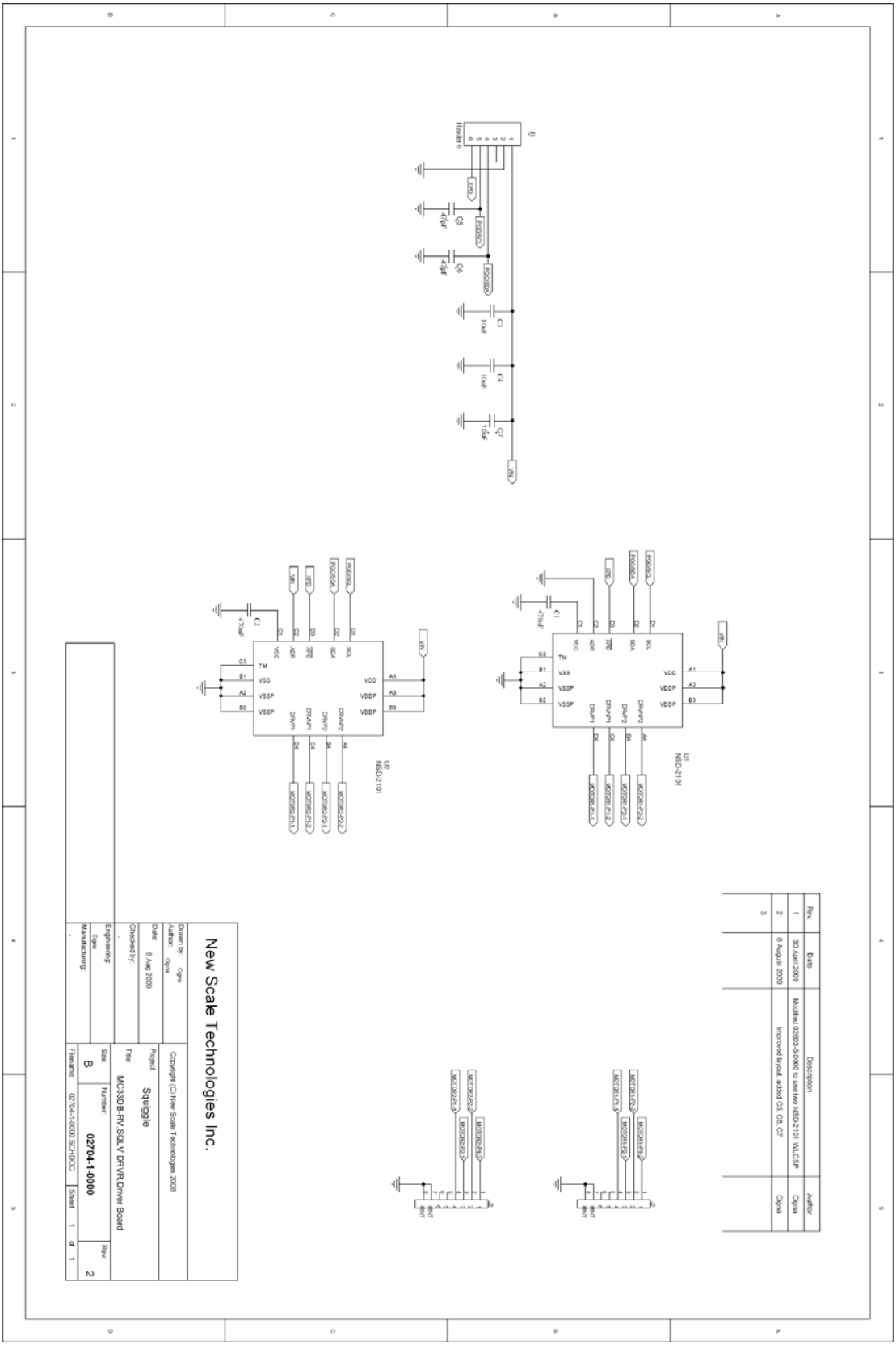
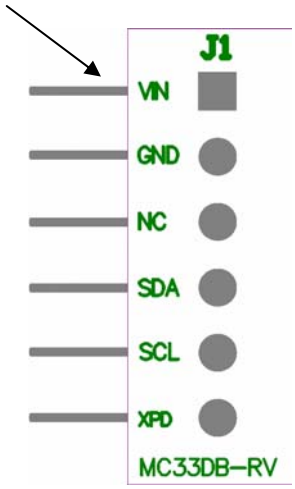


Figure 7. Daughter Board Schematic (1 of 1).

NSD-2101 I²C Control

This section is intended for use by individuals who will be interfacing directly to the MC-33DB-RV daughter board (rather than via the MC-33MB Mother Board).

The connector pins of - the MC-33DB-RV Board which contains the NSD-2101 Motor Driver



Note: The XPD input (above) must be HIGH in order to communicate with the NSD-2101

The I²C interface is used to control the NSD-2102 SQL Motor Driver chip (via the MC-33DB-RV Daughter board) and to set the value of several registers. These registers will define the output voltage (by changing the resistive feedback divider) as well as the direction and duration of the output driver signals. Period count and pulse count registers can be set separately for both motors.

A HIGH to LOW transition on the SDA line while SCL is HIGH is the start condition for the bus. A LOW to HIGH transition on the SDA line while SCL is HIGH is the stop condition.

Every byte put on the SDA line must be 8-bits long. Each byte has to be followed by an acknowledge bit. Data is transferred with the most significant bit (MSB) first.

Data transfer with acknowledge is obligatory. The acknowledge-related clock pulse is generated by the master. The receiver must pull down the SDA line during the acknowledge clock pulse.

The NSD-2101 is a slave device on the bus. The device can be addressed using 7-bits addressing.

There are two different access modes to the slave possible. These are:

- byte write
- page write

Provision will be made for data collision due to non-synchronization between the external clock and the internally generated clock.

7-Bit Addressing: the first 6 bits are fixed (could be modified by metal mask change) and the last bit can be set via package pin.

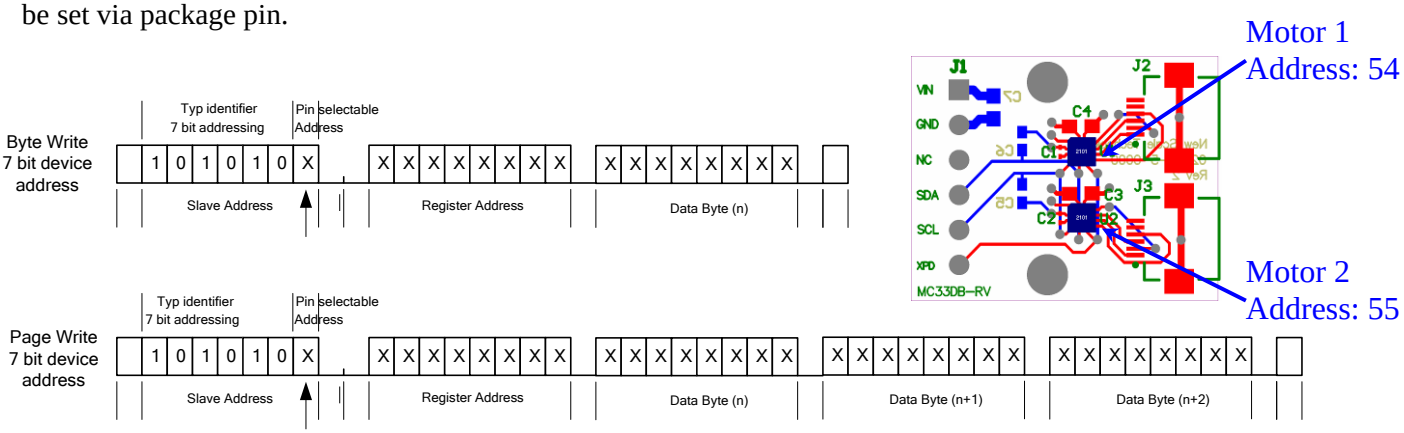


Figure 8. 7-Bit Addressing (54 and 55 Hexadecimal Respectively)

Register Map

The table below shows the registers which can be addressed over the I²C interface.

Description	Address	Data Byte								Note
		MSB							LSB	
Control Register	00h		PS[1]	PS[0]		CN[1]	CN[0]	P1	P2	
Period count	01h	X	X	X	X	X	X	X	X	
Pulse count (high byte)	02h	P	D	DS[1]	DS[0]		X	X	X	(1)
Pulse count (low byte)	03h	X	X	X	X	X	X	X	X	
Pulse width	04h	X	X	X	X	X	X	X	X	
Phase shift	05h	X	X	X	X	X	X	X	X	
Period offset	06h	IDL	HB	HYB	DT		X	X	X	(2)
Hybrid speed	07h	X	X	X	X	X	X	X	X	(4)
Reserved register	10h	X	X	X	X	X	X	X	X	(3)

Notes:

(1) P: period count MSB; D: direction bit; DS: dead time selection bits: '00'=2, '01'=4, '10'=6 and '11'=8 VCO clocks;

(2) CN needs to be 00 to enable Period offset, Period offset is not used when either Incremental or Sweep Frequency Tracking is active. IDL: sets idle mode; HB: enable half bridge operation if VDD > $HB_{th;}$ HYB: enable hybrid speed control; DT: enable signal for increased dead time; Selection bits(DS[1:0]) are only valid when DT=1; Selection bits should not be changed when the output driver is active.

(3) Reserved register used for device test only, not accessible during normal operation.

(4) Hybrid Speed register: 0 .. half bridge; 128 .. full bridge operation; linear transition for values in between; Default: 128. Values from 1 to 127 are used for linear speed control.

Control Register

The control register is used to trigger frequency calibration as well as to select and enable the drive phases.

Control flag mask	Abbr	Default	Description
1000 0000		0	Reserved (leave 0)
0100 0000	PS[1]	1	Phase Select for sensing: PS[1] PS[0]:
0010 0000	PS[0]	1	00=None; 01=Phase1; 10=Phase2; 11= Both Phases;
0001 0000		0	Reserved (leave 0)
0000 1000	CN[1]	0	Calibrate Now: CN[1] CN[0]:
0000 0100	CN[0]	0	00=None; 01=Incremental; 10=Sweep; 11=reserved;
0000 0010	P1	1	Enable Phase1
0000 0001	P2	1	Enable Phase2

Period Counter

The period counter is used to define the switching frequency of the motor. The pulse period is generated by dividing the internal VCO clock frequency by the given period counter value. The MSB of high byte of the pulse counter (p) is used as MSB of the period counter.

At 25MHz clock a decimal period counter value of 125 gives an output frequency of 200 kHz. A period counter value of 126 results in a switching frequency of 198.41 kHz. This is equal to a maximum frequency step of 1.59 kHz. The frequency resolution gets better for lower switching frequencies assuming a fixed VCO clock frequency.

In the following table a few examples are given to define period counter and output switching frequency relation ship. The values are given for 25MHz typical VCO clock frequency.
The switch frequency is given as: f_D = 25MHz / period counter value;

Period counter value	Typ	Unit
0 0111 1101	200.00	kHz
0 0111 1110	198.41	kHz
0 1000 1010	181.16	kHz
0 1010 0110	150.60	kHz
0 1010 0111	149.70	kHz
1 1111 0011	50.10	kHz
1 1111 0100	50.00	kHz

Pulse Counter

The pulse counter sets the number of pulses the motor should be active. When a new value is written to the pulse count register an internal counter is started to count generated output pulses. Writing all zeros to the pulse counter stops the motor even if the previous set counter value is not completed, all outputs pulled to ground. The same is valid for power down mode. Bit 6 in the pulse counter (d) is used to set the direction of motor motion.

Pulse counter value	Typ	Unit	Conditions
XXXX X000 0000 0000	0	pulses	Motor is off, driver outputs are low
XXXX X100 0000 0000	1024	pulses	
XXXX X111 1111 1111	2047	pulses	Maximum possible number of pulses

Pulse Width Control

A register is used to define the duty cycle of the driver output signal. The default value for this register set during power up or power down (XPD = LOW) is equal to 00h. In this case the default duty cycle of 50% is generated. The resulting duty cycle and resolution of single steps is depending on the master clock frequency and the switching frequency of the driver output. In the following table an example for 25MHz master clock and 200kHz driver frequency is given. The value of the duty cycle register should not exceed 50.4% of the period counter value. Pulse Width Modulation is used for speed control when motor is operating in half bridge mode.

Pulse width register	Typ	Unit	Conditions
0000 0000	49.6/50.4	%	default
0000 0001	0.8	%	
0000 1101	10.4	%	
0001 1011	21.6	%	
0011 0101	42.4	%	
0011 1110	49.6	%	
0011 1111	50.4	%	

If operating in half bridge mode, the pulse width can be used to adjust speed. At 50% the motor will operate at its maximum speed. To reduce the speed, the pulse width may be reduced. However, below ~15%, there may not be enough energy in the signal to move the motor.

Phase Shift

A register is used to define the phase shift between the two phases of the driver output signal. The default value for this register set during power up or power down (XPD = LOW) is equal to 00h. In this case the default phase shift of 90° is generated. The resulting phase shift and resolution of single steps is depending on the master clock frequency and the switching frequency of the driver output. In the following table an example for 25MHz master clock and 200kHz driver frequency is given. The value of the phase shift register should not exceed 50.4% of the period counter value. Negative phase shift values are achieved by changing the direction bit: -160deg = 20deg and inverted direction bit.

Phase shift register	Typ	Unit	Conditions
0000 0000	90.5	deg	Default (Normal for both SQL and UTAF)
0000 0001	2.88	deg	
0000 1101	37.44	deg	
0000 1110	40.32	deg	
0001 1111	89.28	deg	
0010 0000	92.16	deg	

Period Offset

Period Offset register defines the offset which is added to the period counter to shift the switching frequency. It also provides some additional control bits.

This offset is only activated when frequency tracking is stopped. An offset has been provided as some types of motors operate better at slightly below mechanical resonance. The table below gives an example for 25MHz master clock and 200kHz nominal driver frequency. Period offset is only supposed to lower drive frequency.

Period offset register	Typ	Unit	Conditions
0000 0000	0	%	default, no change of drive frequency
0000 0001	-0.8	%	
0000 0010	-1.6	%	
0000 0111	-5.6	%	Maximum period offset
1000 0000	0	%	Idle mode enabled
0100 0000	0	%	Half bridge mode enabled
0010 0000	0	%	Hybrid speed control enabled
0001 0000	0	%	Increased dead time enabled

Idle mode reduces power consumption while preserving the most recent frequency calibration. To further reduce power, the XPD pin must be pulled to ground.

Hybrid Speed Register

The hybrid speed register allows the average voltage as seen by the motor to be set from VDD to 2 x VDD. This provides a power efficient method of reducing the speed of the motor. The value of the register can vary from 0 (half bridge) to 128 (full bridge). The average voltage can be calculated in the following manner.

VAVG = VDD + (RegisterValue * VDD/128); Where VDD is the supply voltage.

Hybrid speed register	Typ	Unit	Average Voltage
0000 0000	0	%	VDD (half bridge)
0010 0000	25	%	VDD + 0.25 * VDD
0110 0000	75	%	VDD + 0.75 * VDD
1000 0000	100	%	VDD + VDD (full bridge)

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